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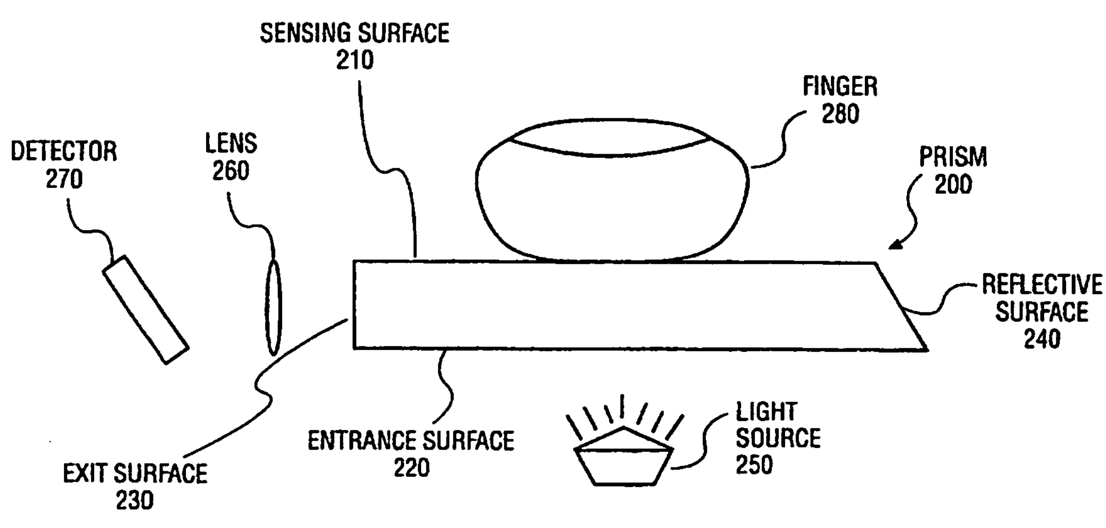
(54) Title: A THIN PRISM FINGERPRINT IMAGER SYSTEM



(57) Abstract: A thin prism for a fingerprint sensor is provided. The prism includes a sensing surface (210) defining a normal. The prism further includes a bottom surface (220) parallel to the sensing surface, and a reflective surface (240), the reflective surface at an angle slightly less than ninety degrees from the normal, the reflective surface for reflecting light rebounding from the sensing surface. The prism further includes an exit surface (230) perpendicular to the sensing surface and the bottom surface, the exit surface for permitting the reflected light to exit from the prism.

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A THIN PRISM FINGERPRINT IMAGER SYSTEM

FIELD OF THE INVENTION

The present invention relates to biometric detection, and more specifically, to fingerprint sensors.

BACKGROUND

FIG. 1 shows a prior art fingerprint sensing system using a single prism with three functional surfaces – the sensing surface 110, the entrance surface 120, and the exit surface 130. A finger 140 is placed on the sensing surface of the prism 100. An extended light source 150 provides illumination for the entrance surface 120. The angle of incidence at the entrance surface 120 is typically at about 90 degrees, and the angle of incidence at the sensing surface 110 is about 45 degrees, which is larger than the critical angle of the prism 100. One portion of the incident radiation at the sensing surface 110 is reflected through total internal reflection, and another portion is not. Where ridges on the finger 140 are in contact with the sensing surface 110, light will be transmitted into or absorbed by the finger 140. On the other hand, where there are grooves on the finger 140, contacts are not made with the sensing surface 110, and the incident light is reflected from the sensing surface 110 through total internal reflection. The reflected light emits from the exit surface and is focused by a lens 160 to create a fingerprint image, which is dark where there are ridges and bright where there are grooves or where the finger is not in contact with the sensing surface. The lens 160 focuses the fingerprint light pattern onto an electronic detector array 170, such as a CCD camera.

The single prism system creates a good image of a fingerprint. Unfortunately, it is not applicable to many applications. For example, if the system is for replacing a mechanical key for a door, the system is best mounted inside the door. For such an application, in order to fit within the wooden surface of the door, the system has to be thin and flat. Due to the bulkiness of the prism, the single prism system occupies too much space for such applications.

It should be apparent from the foregoing that there is still a need for a fingerprint sensing system that is of similar accuracy as the single prism system, but does not occupy as much space.

SUMMARY OF THE INVENTION

A thin prism fingerprint imager system is described. A prism for a fingerprint sensor, the prism comprises a rectangular prism. The prism includes a sensing surface defining a normal. The prism further includes a bottom surface parallel to the sensing surface, and a reflective surface, the reflective surface at an angle slightly less than ninety degrees from the normal, the reflective surface for reflecting light rebounding from the sensing surface. The prism further includes an exit surface perpendicular to the sensing surface and the bottom surface, the exit surface for permitting the reflected light to exit from the prism.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention is illustrated by way of example, and not by way of limitation, in the figures of the accompanying drawings and in which like reference numerals refer to similar elements and in which:

Figure 1 is a prior art fingerprint recognition system.

Figure 2 is one embodiment of a fingerprint recognition system according to the present invention.

Figure 3 illustrates one embodiment of the prism 210 of Figure 2.

Figure 4 is another embodiment of the fingerprint recognition system.

Figure 5 illustrates one embodiment of the prism 410 of Figure 4.

Figure 6 shows another embodiment of the fingerprint recognition system.

Figure 7 illustrates one embodiment of the prism 610 of Figure 6.

Figure 8 illustrates an exemplary prism showing relative dimensions.

DETAILED DESCRIPTION

A fingerprint sensor having a new type of prism is described. The prism has a small footprint, permitting the sensor to be small.

FIG. 2 shows a fingerprint sensing system using the thin prism of the present invention. A finger 280 is placed on the sensing surface of the prism 200. An extended light source 250 provides direct illumination for the entrance surface 220. The angle of incidence at the entrance surface 220 is typically at about 90 degrees.

One portion of the incident radiation at the sensing surface 210 is reflected through total internal reflection, and another portion is not. Where ridges on the finger 280 are in contact with the sensing surface 210, light will be transmitted into or absorbed by the finger 280. On the other hand, where there are grooves on the finger 280, contacts are not made with the sensing surface 210, and the incident light is reflected from the sensing surface 210 through total internal reflection. The reflected emits from the exit surface 230 and is focused by a lens 260 to create a fingerprint image, which is dark where there are ridges and bright where there are grooves or where the finger is not in contact with the sensing surface 210. The lens 260 focuses the fingerprint light pattern onto an electronic detector array 270, such as a charged coupled device (CCD) camera.

For one embodiment, the lens 260 is a corrective lens. For one embodiment, because of the thinness of the prism 200, the fingerprint image received by the detector 270 is compressed. For one embodiment, this compression is at least partially corrected by the lens 260. For one embodiment, further image correction is done by the detector 270. Alternatively, the correction may be done during processing, or not done at all, if the same type of sensor is used for registration and matching.

Figure 3 illustrates one embodiment of the prism 200 of Figure 2. The prism 200 includes sensing surface 210, entrance surface 220, exit surface 230, and reflective surface 240. A light source (not shown) shines a diffuse light 310 at the bottom, or entrance surface 220. The light 310 impacts the sensing surface

210, which has a finger on it. As discussed above, those portions of the light which do not impact the finger, are reflected, 320. This reflected light 320 is bounced back to the entrance surface 220, and is reflected as light 330. The light 330 is reflected by the reflecting surface 240, and exits the prism 200 through the exit surface 230. In this way, the light travels around the prism, and produces an image of the fingerprint placed on the sensing surface 210. Side view 300, shows multiple light waves reflecting in the prism 200.

The dimensions of prism 200 can vary, and sizing may be traded off for distortion. The actual dimensions are chosen based on the location – if having a thin prism is a vital concern, a thinner prism may be used than if the thinness is of less importance. The balancing factors are the level of distortion versus the thinness of the prism. For one embodiment, the sensing surface 210 and the bottom surface 220 are 17 mm wide, the bottom surface 220 is 40.9 mm long, the prism 200 is 5.4 mm high, and the reflecting surface 240 is 82.28 degrees from the normal, defined by the plane of the sensing surface 210. For another embodiment, the ratio between the length and height of the prism is between 7 and 8, when the angle of the reflecting surface 240 is between 75 and 85 degrees. For one embodiment, the relationship between the height and width of the prism and the angle of the working surface is defined by the ratio, shown in Figure 8,

$$Y = \frac{3}{2} * \frac{H^2}{L * \cos\varphi} + H$$

- Where Y is the length of the image capture region, or linear field of view. For one embodiment, Y is 20 mm.
- H and L are height and length of the prism, and
- φ is the working angle. φ may be as small as the total internal reflection angle for the material, and could theoretically approach 90 degrees. For one embodiment, φ is between 40 degrees and 90 degrees.

Figure 4 is another embodiment of the fingerprint recognition system. A finger 480 is placed on the sensing surface 410 of the prism 400. An light source 450 provides diffuse illumination, from the first surface 430.

One portion of the incident radiation at the sensing surface 410 is reflected through total internal reflection, and another portion is not. Where ridges on the finger 480 are in contact with the sensing surface 410, light will be transmitted into or absorbed by the finger 480. On the other hand, where there are grooves on the finger 480, contacts are not made with the sensing surface 410, and the incident light is reflected from the sensing surface 410 through total internal reflection.

The reflected emits from the exit surface 430 and is focused by a lens 460 to create a fingerprint image, which is dark where there are grooves or where the finger is not in contact with the sensing surface 410, and bright where there ridges in the finger. The lens 460 focuses the fingerprint light pattern onto an electronic detector array 470, such as a charged coupled device (CCD) camera.

Figure 5 illustrates one embodiment of the prism 400 of Figure 4. View 505 is a side view of prism 400, while view 507 is a top view of the prism 400. Diffuse light is provided by light sources 550. For one embodiment, light sources 550 are a plurality of light emitting diodes (LEDs). For one embodiment, light guide tape (not shown) may be used with the diffuse surface lighting 550.

Figure 6 shows another embodiment of the fingerprint recognition system. A finger 680 is placed on the sensing surface of the prism 600. An light source 650 provides illumination through the reflective surface 640. For one embodiment, this light source 650 points downward, as is shown by the illustration of the light path in Figure 7.

One portion of the incident radiation at the sensing surface 610 is reflected through total internal reflection, and another portion is not. Where ridges on the finger 680 are in contact with the sensing surface 610, light will be transmitted into or absorbed by the finger 680. On the other hand, where there are grooves on the finger 680, contacts are not made with the sensing surface

610, and the incident light is reflected from the sensing surface 610 through total internal reflection. The reflected emits from the exit surface 630 and is focused by a lens 660 to create a fingerprint image, which is dark where there are ridges and bright where there are grooves or where the finger is not in contact with the sensing surface 610. The lens 660 focuses the fingerprint light pattern onto an electronic detector array 670, such as a charged coupled device (CCD) camera.

Figure 7 illustrates one embodiment of the prism 600 of Figure 6. The light source 650 provides a light 710 at the reflective surface 640. The reflective surface 640 is a cylindrical mirror for distortion correction. Side view 703 shows one embodiment of the reflective surface 640.

The light 710 from the light source 650 is reflected from the first surface 630. The first surface 630, for one embodiment, is also a cylindrical mirror. For one embodiment, the first surface 630 and reflective surface 640 are identical. For another embodiment, the first surface 630 and reflective surface 640 may differ slightly. Cut-away views A-A and B-B show the spherical surfaces 630 and 640 as well.

The light 720 reflected from first surface 630 is reflected from the bottom surface 620. For one embodiment, the bottom surface 620 is mirrored, or its reflective ratio is enhanced in another way. The light 730 reflected from the bottom surface 630 is reflected to the sensing surface 610. On the sensing surface 610, the fingerprint image is picked up. The light 740 reflected from the sensing surface 610, is again reflected from the bottom surface 630. From the bottom surface 630, the light 750 is reflected by the reflecting surface 640, to the lens 660. In this way, through multiple reflections, the prism 600 transmits an image of the fingerprint on the sensing surface 610 to the lens.

In the foregoing specification, the invention has been described with reference to specific exemplary embodiments thereof. It will, however, be evident that various modifications and changes may be made thereto without departing from the broader spirit and scope of the invention as set forth in the

appended claims. The specification and drawings are, accordingly, to be regarded in an illustrative rather than a restrictive sense.

CLAIMS

What is claimed is:

1. A prism for a fingerprint sensor, the prism comprising a rectangular prism having:

a sensing surface defining a normal;

a bottom surface parallel to the sensing surface;

a reflective surface, the reflective surface at an angle slightly less than ninety degrees from the normal, the reflective surface for reflecting light rebounding from the sensing surface; and

an exit surface perpendicular to the sensing surface and the bottom surface, the exit surface for permitting the reflected light to exit from the prism.

2. The prism of claim 1, wherein the angle of the reflective surface is 75 to 85 degrees from the normal.

3. The prism of claim 2, wherein the angle is 81.28 degrees.

4. The prism of claim 1, wherein the prism is 4 to 10 millimeters thick.

5. The prism of claim 1, wherein the prism has a height, a width, and a length, measured along the bottom surface.

6. The prism of claim 5, wherein the height is approximately one eighth of the length.

7. The prism of claim 5, wherein the length is approximately 2.4 times the width of the prism.

8. The prism of claim 1, wherein the sensing surface and the bottom surface are 17 mm wide, the bottom surface is 40.9 mm long, the prism is 5.4 mm high, and the reflecting surface is 82.28 degrees from the normal.

9. The prism of claim 1, wherein a diffuse light source is shined through the exit surface, to illuminate a finger placed on the sensing surface, thereby producing a negative image.

10. The prism of claim 1, wherein a light source is shined through the bottom surface, to illuminate a finger placed on the sensing surface, thereby producing a positive image.

11. The prism of claim 1, wherein a light source is shined through the reflective surface.

12. The prism of claim 1, wherein the bottom surface, the exit surface, and the reflective surface are treated to reflect a large percentage of light.

13. The prism of claim 12, wherein a small area of a surface is untreated to permit light from a light source to enter the prism.

14. The prism of claim 13, wherein the light source is a light emitting diode (LED).

15. A fingerprint sensing system comprising:

a prism having:

a sensing surface defining a normal;

a bottom surface parallel to the sensing surface;

a reflective surface, the reflective surface at an angle slightly less than ninety degrees from the normal, the reflective surface for reflecting light rebounding from the sensing surface; and

an exit surface perpendicular to the sensing surface and the bottom surface, the exit surface for permitting the reflected light to exit from the prism;

such that when a finger is positioned on the sensing surface, a portion of illumination radiation illuminating the system, entering an entrance surface and incident at the sensing surface is reflected through total internal reflection and is reflected from the reflective surface and emitted from the exit surface to create an image of the fingerprint.

16. The fingerprint sensing system of claim 15, wherein the angle is between 75 and 85 degrees from the normal.

17. The fingerprint sensing system of claim 15, further comprising:

a light source for illuminating a finger placed on the sensing surface, an image of the finger exiting the prism through the exit surface.

18. The fingerprint sensing system of claim 15, further comprising:

a lens for focusing light including the image of the finger, exiting through the exit surface.

19. The fingerprint sensing system of claim 18, wherein the lens is a correcting lens, correcting for a distortion of the fingerprint image.

20. The fingerprint sensing system of claim 15, further comprising:

a detector for detecting the light exiting through the exit surface.

21. The fingerprint sensing system of claim 20, wherein the detector is a charge coupled device (CCD).

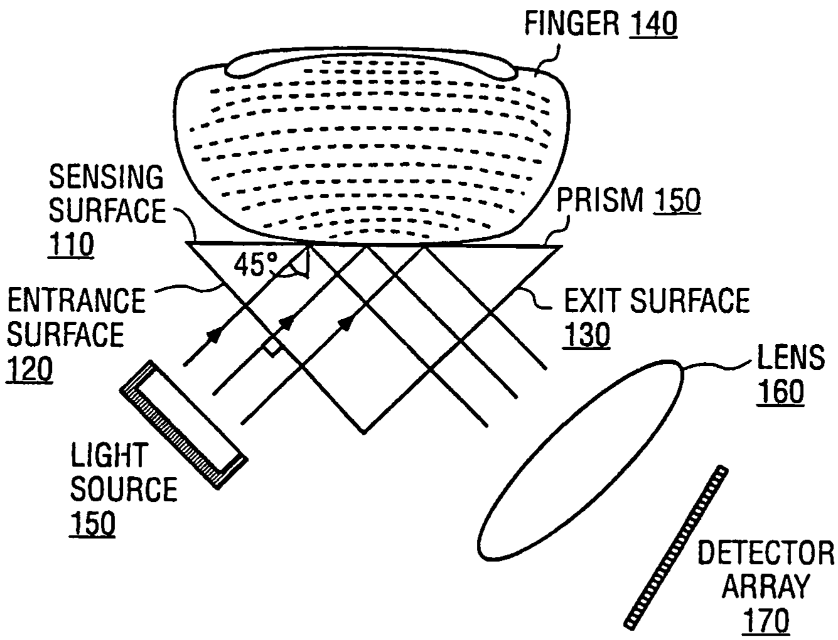

FIG. 1
(PRIOR ART)

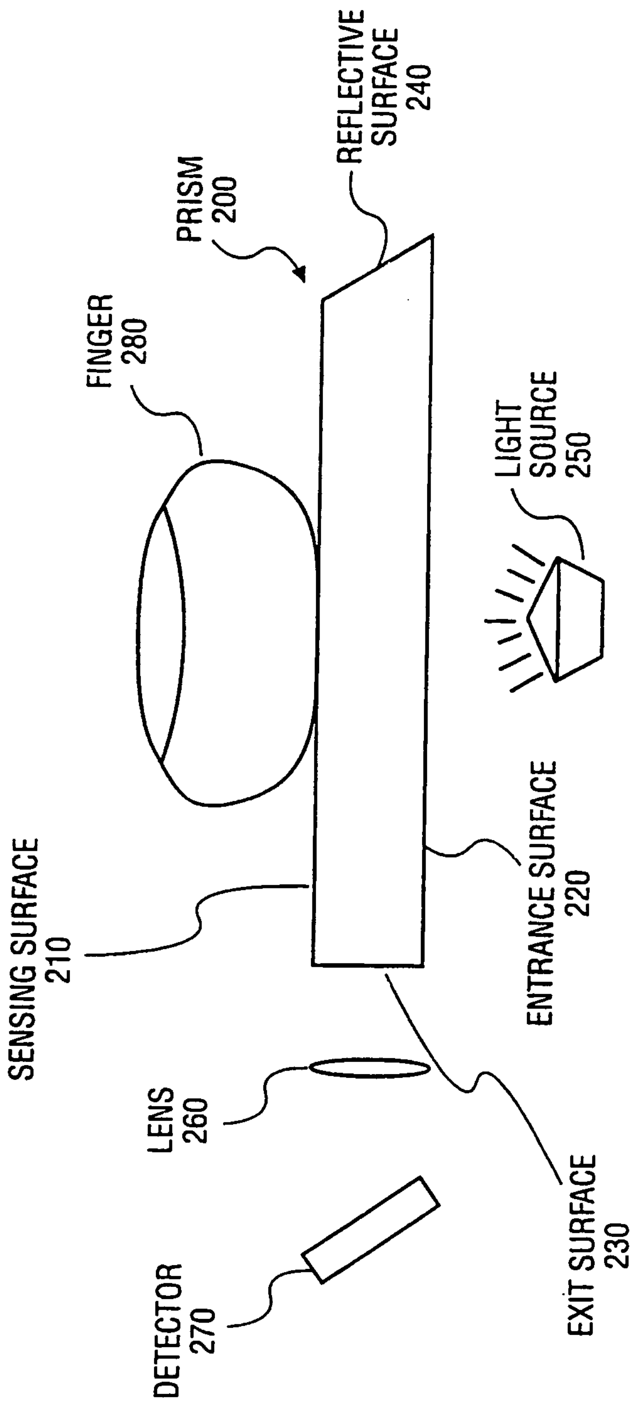
PRISM 200
REFLECTIVE SURFACE 240
FINGER 280
LIGHT SOURCE 250
SENSING SURFACE 210
ENTRANCE SURFACE 220
LENS 260
EXIT SURFACE 230
DETECTOR 270

FIG. 2

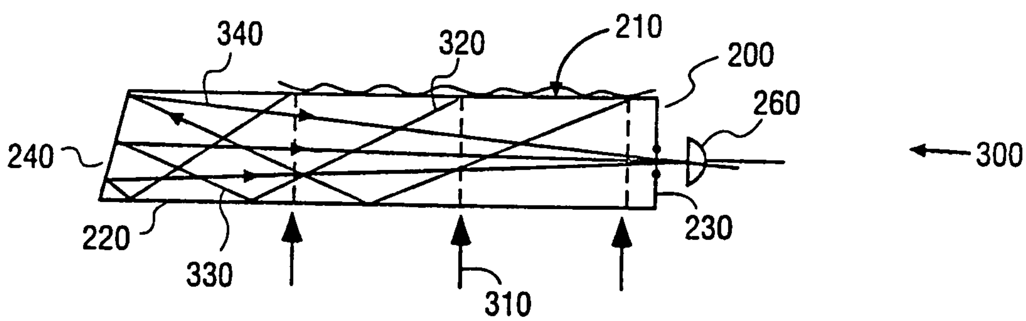

FIG. 3

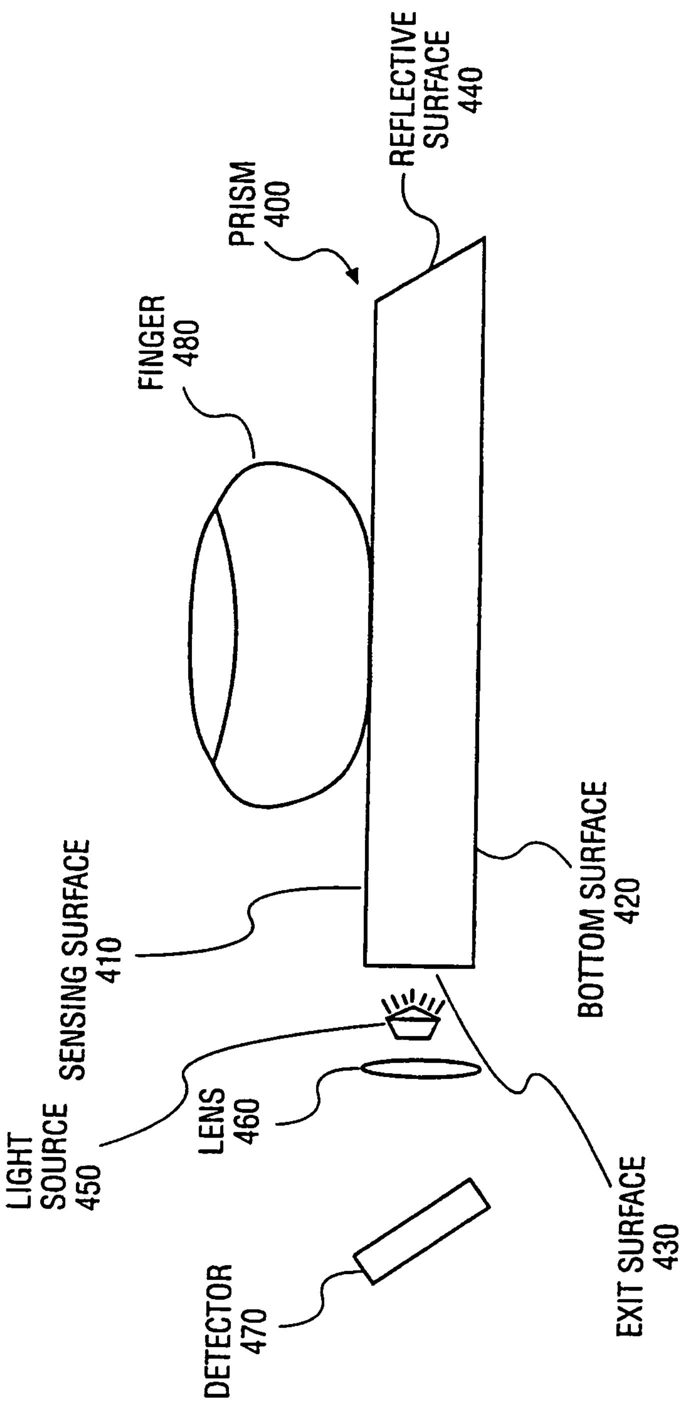
REFLECTIVE SURFACE 440
PRISM 400
FINGER 480
SENSING SURFACE 410
BOTTOM SURFACE 420
LIGHT SOURCE 450
LENS 460
EXIT SURFACE 430
DETECTOR 470

FIG. 4

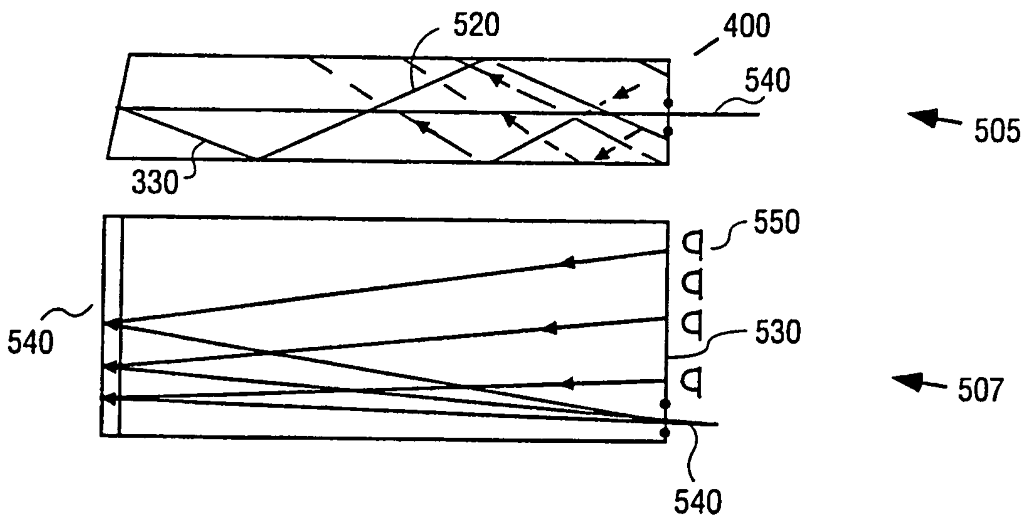

FIG. 5

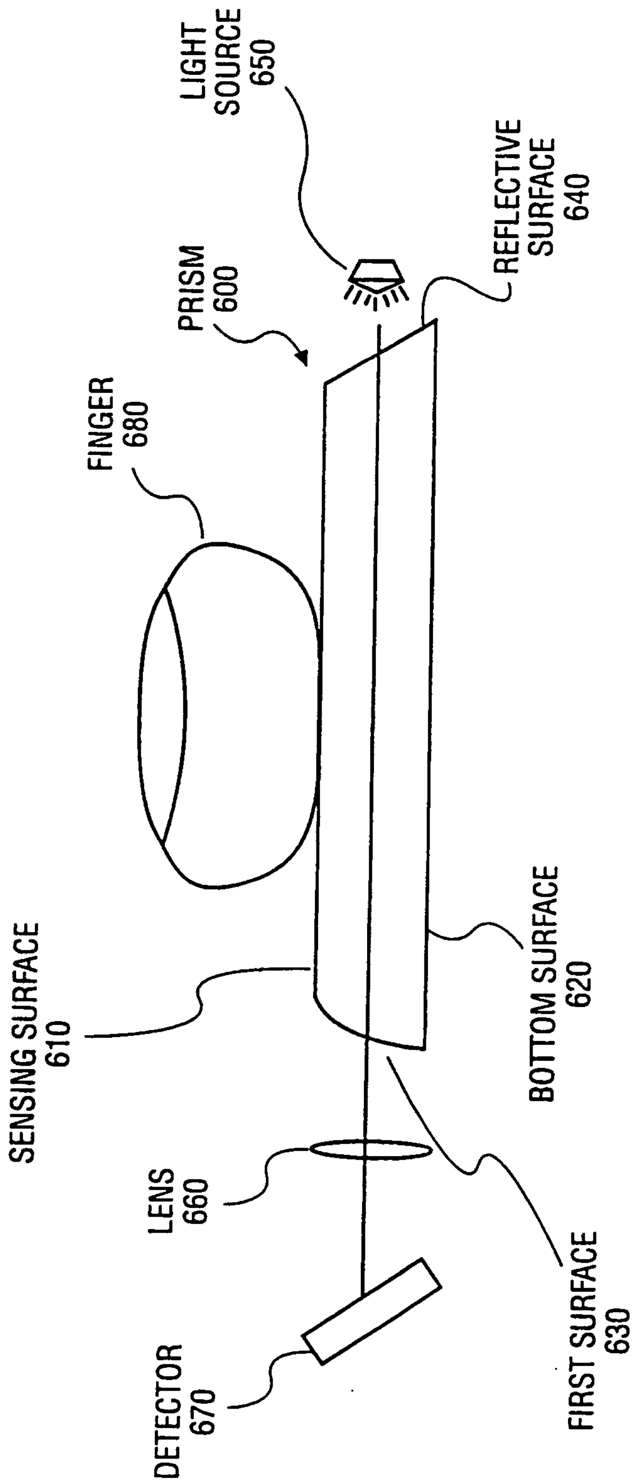
LIGHT SOURCE 650
PRISM 600
REFLECTIVE SURFACE 640
FINGER 680
SENSING SURFACE 610
BOTTOM SURFACE 620
LENS 660
FIRST SURFACE 630
DETECTOR 670

FIG. 6

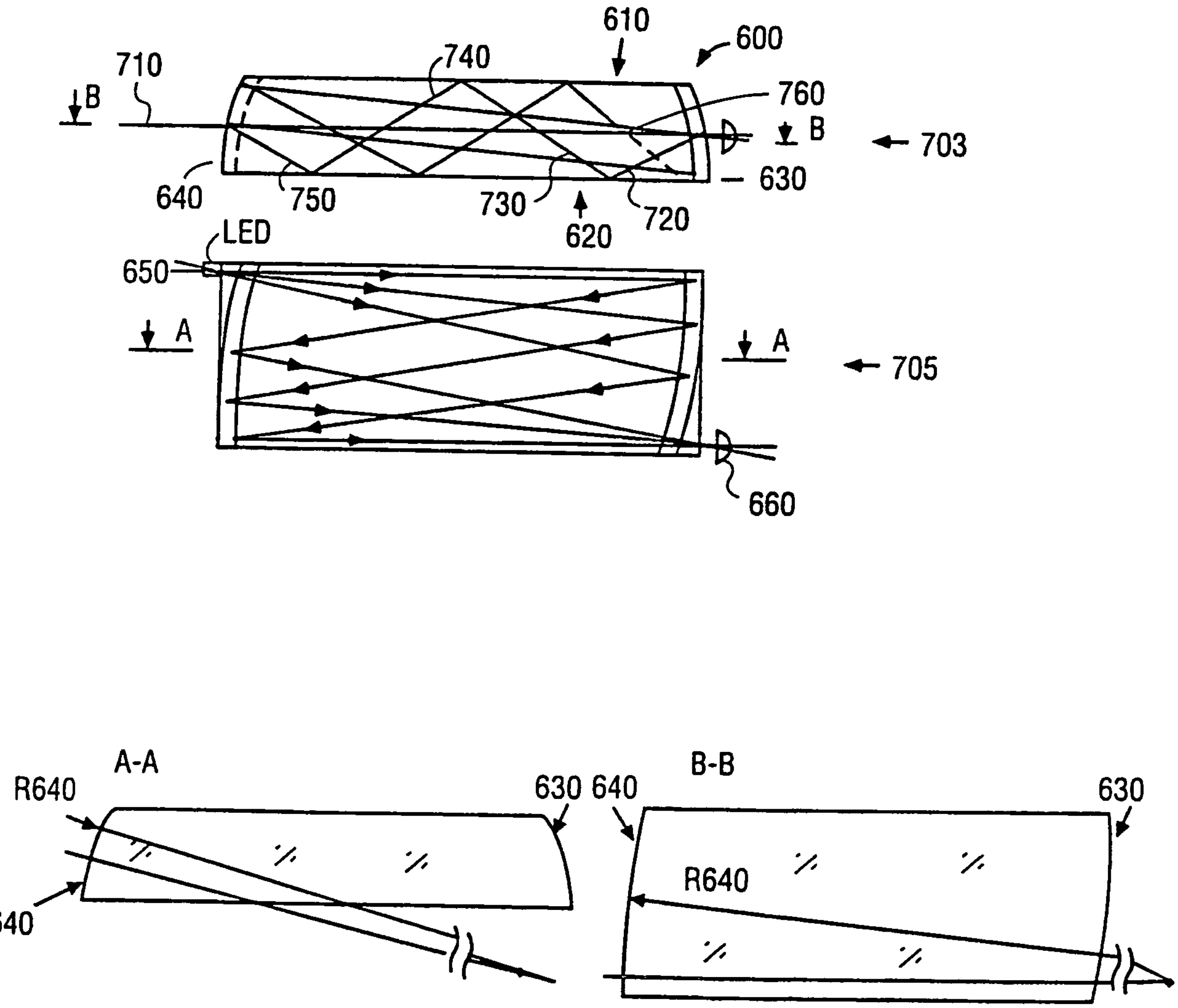
610
600
710
740
760
B
B
703
640
750
730
620
720
630
LED
650
A
A
705
660
A-A
R640
630
640
640
B-B
630
R640

FIG. 7

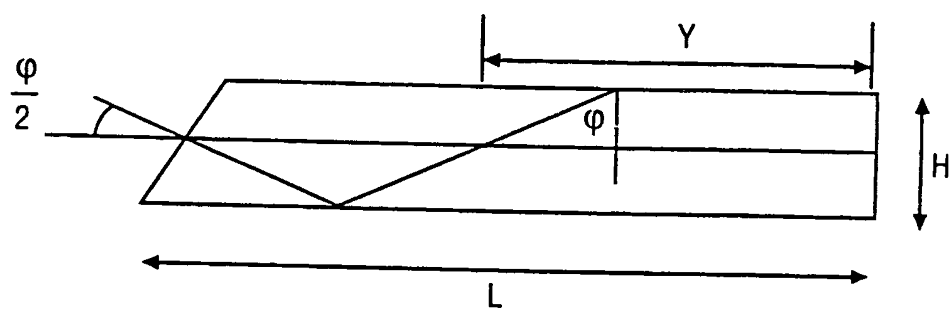

FIG. 8

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US00/24669

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) : G06K 9/20
US CL :382/127
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 382/124, 125, 126, 127, 275, 312, 315; 356/71; 340/825.31, 825.32, 825.33, 825.34; 235/382; 396/15; 359/638, 833, 834

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

IEEE and EPO, JPO, DERWENT ABSTRACTS AND US PATENT TEXT USING EAST

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X ---- Y	US 5,621,516 A (SHINZAKI et al.) 15 APRIL 1997, figures 1, 5 and 8.	1-5, 9-11 15-21 -------------- 6-8, 12-14
Y	US 5,596,454 A (HEBERT) 21 JANUARY 1997, column 6, lines 1-13 and column 10, lines 57-64.	6-8, 12-14

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:

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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

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